Environmental Sustainability in Museum Architecture in Previously Existing Buildings: Tools for Decision-Making

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In Brazil the interest in museums is growing steadily, and in the beginning of the century it achieved significant importance, that led to the creation of a specific body to take care of the Brazilian museums, the Brazilian Institute of Museums / IBRAM.

In 1818 it was created the first museum in Brazil, the Royal Museum, which was installed in existing buildings in the city of Rio de Janeiro.

In 1892 the museum was installed in the old imperial residence, which was unoccupied, in alignment with the preservation policy and European politics of national identity.
3462 MUSEUMS HAVE BEEN IDENTIFIED IN BRAZIL

CNM / IBRAM / MinC
October of 2013

1668 museums registered
1794 museums not registered

1607 MUSEUMS HAVE REPORTED ABOUT THEIR BUILDINGS

270 museum buildings
16.8% built for museum use

1337 museums building - 83.2% adapted for museum use

1357 MUSEUMS REPORTED ABOUT THEIR PREVIOUSLY EXISTING BUILDINGS

482 museums - 36.1% protected by preservation law

855 museums - 63.9% old building not protect by preservation law
To understand the architecture of museums that has been produced in Brazil since the early nineteenth century, it is necessary to know the different levels of connection between museums and existing buildings.

In Brazil the adjustments undertaken in the old museum building begin to develop sustainable practices and use bioclimatic strategies in the search for human comfort conditions and environmental control for collections.
Botafogo neighborhood - city of Rio de Janeiro - Brazil
Both museums are installed in historic buildings adapted for museum use.

We have used the example of historic buildings, because they are the most restrictive.
We have performed temperature, relative humidity and lighting measurements in the three places, with one hour interval and over the period of one year.

HOBO data logger U12-012
So our challenge is to conceive a methodology to assist decision making in architectural design for pre-existing adapted museums buildings.

In this Givoni diagram it is depicted the zone for human environmental comfort and identified other adjacent areas, with the strategies that should be adopted for achieving environmental comfort.
In Climate Conference - Climate for Collections - Lukasz Bratasz has systematized data on temperature and relative humidity. In his article are gathered the main institutions dedicated to the subject, that identified limits for conservation:

We have included in the Bioclimatic Diagram of Givoni these parameters identifying another zone:

- 1978 - Garry Thomson __ Class I: temperature between 19°C and 24°C and relative humidity of 50% to 55% (+/- 5 °C) and class 2 fairly constant temperature and relative humidity of 40% to 70%;
- 1979 - Canadian Conservation Institute __ T = 20 °C to 25 °C and RH = 47% to 53% (long-term average), 38% to 55% (seasonal cycle), +/- 2% (short-term fluctuations);
- 1994 - National Trust __ T = 5 °C to 22 °C and RH = 58% (long-term average), 50% to 65% (alarm level 1), 40% to 75% (alarm level 2);
- 1999 - ASHRAE __ T = 15 °C to 25 °C and RH = 50% +/- 10% and below 75%;
- 2006 - National Trust __ T = 5 °C to 22 °C and RH = 50% to 65%;
- 2007 - Smithsonian Institution __ T = 21 °C and RH = 45% +/- 8%;
- 2009 - National Museum Directors Conference UK __ T = 16°C to 25°C and 40% RH = 60%;
- 2010 - European Standard IN 15757 2010 __ T = not specified and UR = annual historical averages and the seasons +/- 10%;(Bratasz, 2013)
ZONES:
1. Comfort
2. Ventilation
3. Evaporative Cooling
4. High Inertia Thermal for Cooling
5. Air Conditioning
6. Humidification
7. High Inertia Thermal / Solar Heating
8. Passive Solar Heating
9. Artificial Heating
10. Ventilation / High Inertia
11. Vent. / High Inertia / Evap. Cooling
12. High Inertia / Evap. Cooling
13. Environmental Control for Museum Objects
Diagram 3D - Bioclimatic strategies for architecture, including conservation zone for objects

Villa-Lobos Museum
temperature/humidity/lighting - March 2015

House of Rui Barbosa Museum
temperature/humidity/lighting - March 2015
**UNI 10829 - suggested values for the optimal conservation of works of arts for steady-state indoor climate conditions**

<table>
<thead>
<tr>
<th>Material (Artistic)</th>
<th>$q_0$ (°C)</th>
<th>$Dq_{max}$ (°C)</th>
<th>$u_0$ (%)</th>
<th>$D_{u_{max}}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood, musical instruments</td>
<td>19-24</td>
<td>1.5</td>
<td>45-65</td>
<td>2%</td>
</tr>
<tr>
<td>Books of great value, leather-bound books, leather bindings, parchment, miniatures</td>
<td>19-24</td>
<td>1.5</td>
<td>45-65</td>
<td>6%</td>
</tr>
</tbody>
</table>

**Mean monthly value of the air temperature - $q_0$**

**Daily range of air temperature - $Dq_{max}$**

**Mean monthly value of the relative humidity of indoor air - $u_0$**

**Daily range of relative humidity of air - $D_{u_{max}}$**
MARCH 2015 - daily variations

Graph: Comparison of temperature and humidity between Villa-Lobos Museum and House of Rui Barbosa Museum over March 2015.

Temperature:
- Villa-Lobos Museum: Blue line
- House of Rui Barbosa Museum: Red line

Humidity:
- Villa-Lobos Museum: Blue line
- House of Rui Barbosa Museum: Red line

Legend:
- Temperature: °C
- Humidity: %

Key:
- Book of Great Value: 6%
- Wood Muse. Instrument: 2%
MARCH 2015 - comparison of moisture in the 3 points measured
Understanding the preservation of museum collections, with reference to the performance of protective layers, helps to see the contribution that the museum architecture can offer to this field, as well as the potential and limits that every old building has in creating a microclimate adequate to preserve the collections at lower cost and power consumption.
From the physical point of view, the Building Envelop performs the separation between the internal and the external environments, offers resistance to air, water, heat transfer, light, noise, but it is also the most visible part of the building, showing its style of expression and architectural form, with great symbolic image and time identification in the cities, especially in historical buildings.

Acting in Building Envelop requires the integration of methodologies such as the preservation of the architecture with bioclimatic architecture.
References:

- CNM Cadastro Nacional de Museus _ National Register of Museums in Brazil, CNM / IBRAM, October 2013;
- GENNUSA, M., LASCARI, M., RIZZO, G. and SCACCIANOCE, G. “Conflicting needs of the indoor thermal environment of museums: in search of a practical compromise”, Science Direct, Palermo, Italy, 2007;
- RIBEIRO, Marina Byrro and CAETANO, Diego made the transformation of the measured data on the HOBO DataLogger Onset U12-012 to CSV data for apply at Analysis Bio LabEEE/UFCS;
THANK YOU

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